Risk Management of Microelectronics:

The NASA Electronic Parts and Packaging (NEPP) Program

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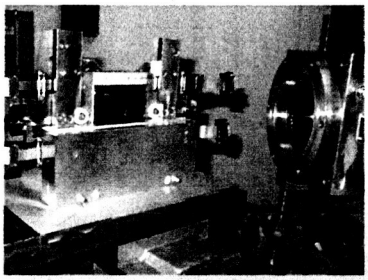
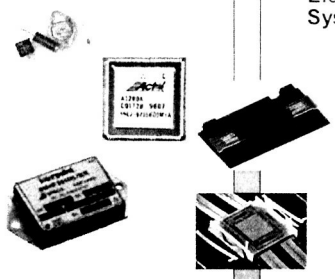


Charge Coupled Device (CCD) ready for protons at UC Davis Crocker Nuclear Lab. Courtesy of NEPP Program and Defense Threat Reduction Agency (DTRA)

EEE Parts

Electrical
- Capacitors
- Resistors
- Transformers
- Wire& Cable
- Connectors

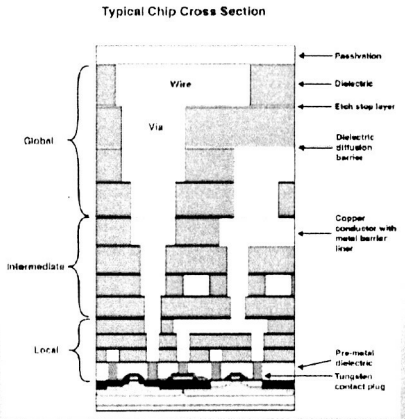
Electronic
- Diodes
- Transistors
- Microcircuits
- Hybrids



Electromechanical
- Relays
- MEMS: Micro ElectroMechanical Systems
- MOEMS: Micro Optical ElectroMechanical Systems

NEPP Mission

- **The NEPP mission is to provide guidance to NASA for the selection and application of microelectronics technologies, to improve understanding of the risks related to the use of these technologies in the space environment and to ensure that appropriate research is performed to meet NASA mission assurance needs.**



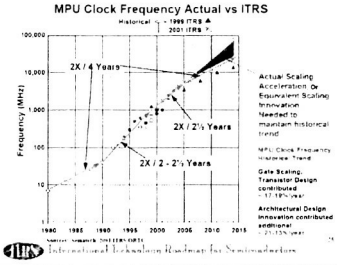
NEPP Overview

- NEPP has been a One NASA success story for more than 15 years; 7 NASA Centers and JPL actively participate
- The NEPP Program focuses on the reliability aspects of electronic devices (integrated circuits such as a processor in a computer or optical components such as might be used in a communication link like in phone lines).
- There are three principal aspects of this reliability:
  - Lifetime, inherent failure and design issues related to the EEE parts technology and packaging,
  - Effects of space radiation and the space environment on these technologies, and
  - Creation and maintenance of the assurance support infrastructure required for mission success.

Electrical overstress failure in a commercial electronic device

NEPP Overview (Continued)

- NEPP interests span EEE parts technologies from those just emerging from research to commonly-used "building block" parts for every mission
- NEPP is multi-disciplinary involving radiation, materials, test, experimentation, process and specification experts across the Agency
- NEPP has close, cooperative and long-standing relationships with government and non-government entities worldwide
- ***NEPP provides a unique capability within the Agency to evaluate technologies in advance of mission needs, to provide assistance with risk management of technology insertion***



Increasing device speed is a challenge for test, validation, and qualification

NEPP Program – Goals and Objectives

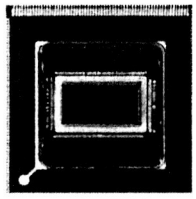
- Main goal – *Mission reliability* to meet NASA exploration and science objectives
  - *Ensure reliability of missions by "smart" investments in EEE parts technology, knowledge gathering and research*
    - Minimize engineering resources required to maximize space and earth science data collection
- NEPP objectives
  - Evaluate NASA needs for and reliability/radiation issues of new and emerging EEE technologies *with a focus on near to mid term needs*
    - **Explore failure mechanisms and technology models**
  - **Develop guidelines for technology usage, selection, and qualification**
  - **Investigate radiation hardness assurance (RHA)/reliability issues**
    - **Increase system reliability and reduce cost and schedule**

"There's a little black spot on the sun today" – A precursor to a solar event

SOHO Image

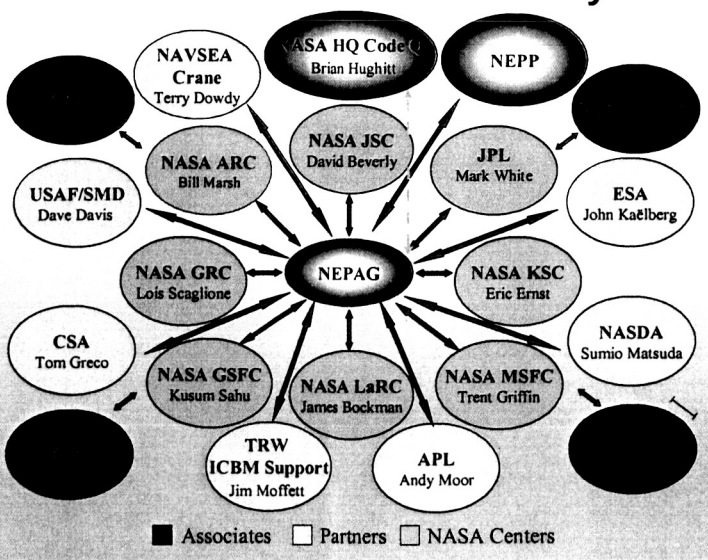
NASA EEE Parts Assurance Group (NEPAG), A Subset of NEPP

- A flexible, multi-entity, multi-national,cooperative group
  - Organized and led by NASA
- Objective: To limit the number of EEE parts failures both on-orbit and on the ground
  - Emphasis is on mature and already deployed technologies
- **Develops tools, shares information & resources as One NASA**
  - **Supports vendor audits, specification reviews and problem part investigations in support of US MIL system**
  - **Supports efforts of non government standards bodies:**
    - **Electronic Industries Alliance (EIA) and JEDEC**
  - **Investigates problems and performs focused evaluations on "basic" technologies, notably passives**
- **Complements NEPP focus and objectives *One Continuum***



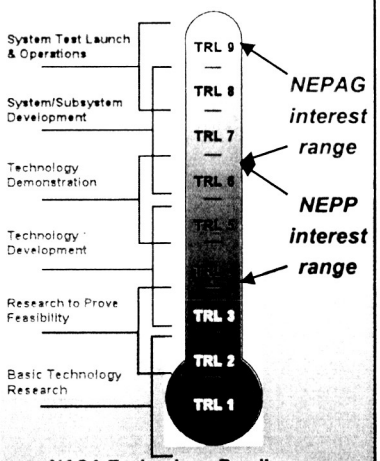
ACTEL RTSX72S FPGA
A part that passed "standard" qualification, but requires more complex testing

NEPAG "Extended Family"



Insertion of New Technologies – A NASA Mission Perspective

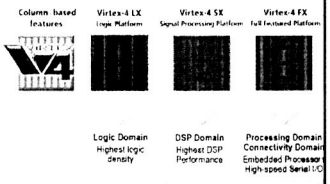
- NASA mission timeframes rarely allow for a technology development path
  - For a 2008 launch, for example, technology freeze dates are likely 2005 or earlier
    - Technology must be moderately mature when a mission is being developed
      - *There may be time to qualify (test) a device, but there may not be time to develop/validate a new technology solution!*
    - Risk versus performance reward for using less mature or commercial off-the-shelf (COTS) technologies
- **Technology development and evaluation programs need to be in place prior to mission design**
  - ***Strategic planning for/by NEPP on technologies is critical***



NASA Technology Readiness Levels (TRLs)

NEPP FY05: Large Issue Focus

- Pre-FY05, NEPP focused on many small efforts providing incremental results
  - Tasks took multiple years to provide product
    - Albeit useful, timeliness was borderline
    - Task-sharing common between centers
      - Managerial challenge for keeping each task focused
  - *Inadequate return for NASA needs*
- **FY05: Fewer efforts, but with larger return per task**
  - **Principle 1: Attack technologies with best return on investment**
    - **Not all major areas able to covered with existing NEPP funding profile**
  - **Principle 2: Utilize "centers of excellence" from existing expertise**
  - **Principle 3: Continue and maximize leverage and partnering**
    - **Technology advancement is rapid**
    - **Procurement of samples and performance of testing is very expensive**
    - **NEPP does not have the resources to "go it alone"**



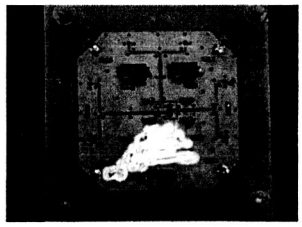
Complex new FPGA architectures include hard-cores: processing, high-speed I/O, DSPs, programmable logic, and configuration latches.
Joint program with AFRL, MDA, and NAVSEA for evaluation

Hypothetical New Technology Part Qualification Cost

Item	*Cost*	*Note*
Parts Procurement (500-1000 devices for testing only)	$25-1000K	Individual device costs can run from cents to tens of thousands
Standard Qualification Tests	$300K	
Radiation Tests and Modeling	$200K	Assumes total dose and single event (heavy ion) only
Failure Modes Analysis	$200K	Out-of-the-box look at the "hows and whats" for non-standard research required for qualification
Additional Tests, Modeling, and Analysis based on Failure Modes	$300K	
Total cost for one device type	$1.025-2M	Not all new technologies will meet standard qualification levels: technology limitations document

The New NEPP Operating Philosophy

- Short list of key technologies
- Proposals in these areas given priority
- Center specialties will also be supported
- Maximize partnerships with other NASA technology programs, government agencies, industry, and academia
- Quality not quantity for deliverables
- Our Goal: NEPP products used by every NASA project



High-speed test fixture for evaluation of emerging technology devices. Fixture designed by Mayo under DARPA and OGA funds. Testing sponsored by NEPP and DTRA.

Sample Partnership Matrix

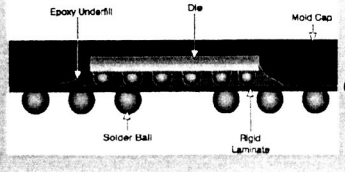
Task Area	Other Government	Industry	University	NASA
SiGe Radiation	DARPA, OGA, AFOSR – in-kind; DTRA – direct funding, in-kind	Jazz Semiconductor, IBM – test samples, Mayo Foundation – mitigation design, packaging	Auburn, Georgia Tech, Arizona State, Vanderbilt – modeling and data analysis	H&RT BAA - (Georgia Tech)
Sensor Technology	AFRL – test samples, joint test; DTRA – direct funding, in-kind	Ball Aerospace, Raytheon, Full Circle Research – joint test and data analysis	U of Arizona, U of Hawaii	Prometheus, JWST, HST WFC3
Emerging NVMs	AFRL, MDA, OGA – in-kind; DTRA – direct funding; NAVSEA Crane, MDA, DTRA – CRAM IPT	BAE Systems – CRAM, Freescale Semiconductor – Si Nanocrystal, LSI Logic /Nantero/Seakr – Carbon Nanotube, Honeywell/Freescale – MRAM	Vanderbilt	Prometheus – co-evaluation CRAM, FeRAM

NEPP Focus Tasks for FY05

- Field Programmable Gate Arrays (FPGA's)
  - Low-cost replacement for custom ASICs
    - Flexibility for reconfigurable systems
  - Reliability and radiation issues
- Non-volatile Memories (NVM's)
  - Used to store program code and, in some cases, flight telemetry
  - The widely-used Hitachi EEPROM is reliability suspect
  - All NVM's have reliability and radiation concerns
- **Advanced Mixed Signal**
  - **NEPP will examine reliability, radiation, and extreme environment performance**
- **Scaled CMOS**
  - **Continuous reduction of feature size**
  - **Reliability and radiation performance unpredictable**
- **Board-Level Radiation Assessment**
  - **Controversial but promises lower cost and application specificity**
- **Lead-free**
  - **NASA can cope with lead-free solder, but lead-free plating??**
  - **Tin whisker threat**

Focus 1: FPGAs

- Why Field Programmable Gate Arrays (FPGA's)?
  - Ubiquitous usage on ALL NASA craft
  - Industry-wide concern
  - Competing philosophies and technologies available
- FY05 NEPP Plans include
  - GSFC
    - Develop qualification guidance via testing for NEW ACTEL RTSX(U) devices
      - Investigate reliability, design, and radiation performance
      - Tie-in to Aerospace Corp-led investigation
    - Provide similar insight into other FPGA devices/technologies
      - **Antifuse and Flash-based devices**
    - **Partner with others for evaluation of state-of-the-art commercial reprogrammable devices**
      - **Tie-ins to Exploration Systems efforts for a Radiation Tolerant FPGA development**
    - **Radiation evaluation of base technologies used on FPGAs**
  - **JPL**
    - **Develop qualification guidance for reprogrammable FPGAs**
      - **Emphasis on Xilinx family, but others to be tested as well**
    - **Support industry-led consortia for radiation testing of Xilinx Virtex-II Pro device**
      - **Xilinx, Seakr, LANL, SNL, other partners**
  - **Develop database of FPGA device knowledge to apply to usage and qualification**



Complex packages complicate "parts" issues